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(54) **DOUBLE-SIDED CIRCUIT BOARD WITH  
OPPOSING MODULAR CARD CONNECTOR  
ASSEMBLIES**

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(71) Applicant: **Jean-Philippe Fricker**, Mountain View,  
CA (US)

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(72) Inventor: **Jean-Philippe Fricker**, Mountain View,  
CA (US)

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(73) Assignee: **Advanced Micro Devices, Inc.**,  
Sunnyvale, CA (US)

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*Primary Examiner* — Andargie M Aychillhum

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See application file for complete search history.

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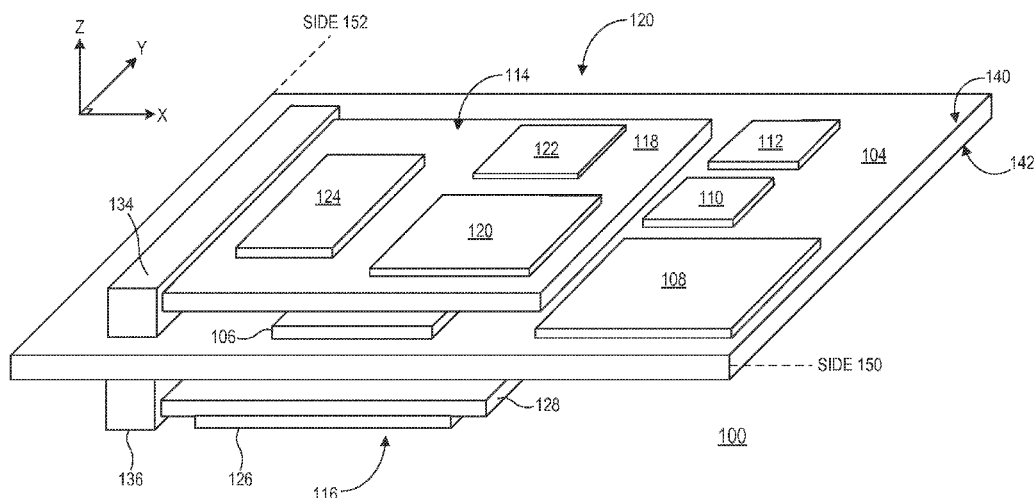
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(57) **ABSTRACT**

An electronic assembly includes a circuit board that serves as both a mechanical attachment point and signal conduit for electronic components. The circuit board includes at least two modular card connector assemblies disposed on opposing surfaces of a mounting region of the circuit board. Pin sets of the modular card connector assemblies are connected together via corresponding through holes extending between the opposing surfaces in the mounting region. Further, pins of one or both the modular card connector assemblies may be connected to other electronic components disposed at the circuit board via lateral traces. One or both of the modular card connector assemblies can comprise a modular card socket to removably couple with a modular card. Alternatively, one or both of the modular card connector assemblies comprises a pin interface assembly that is integral to or otherwise fixedly attached to the modular card.

**22 Claims, 7 Drawing Sheets**



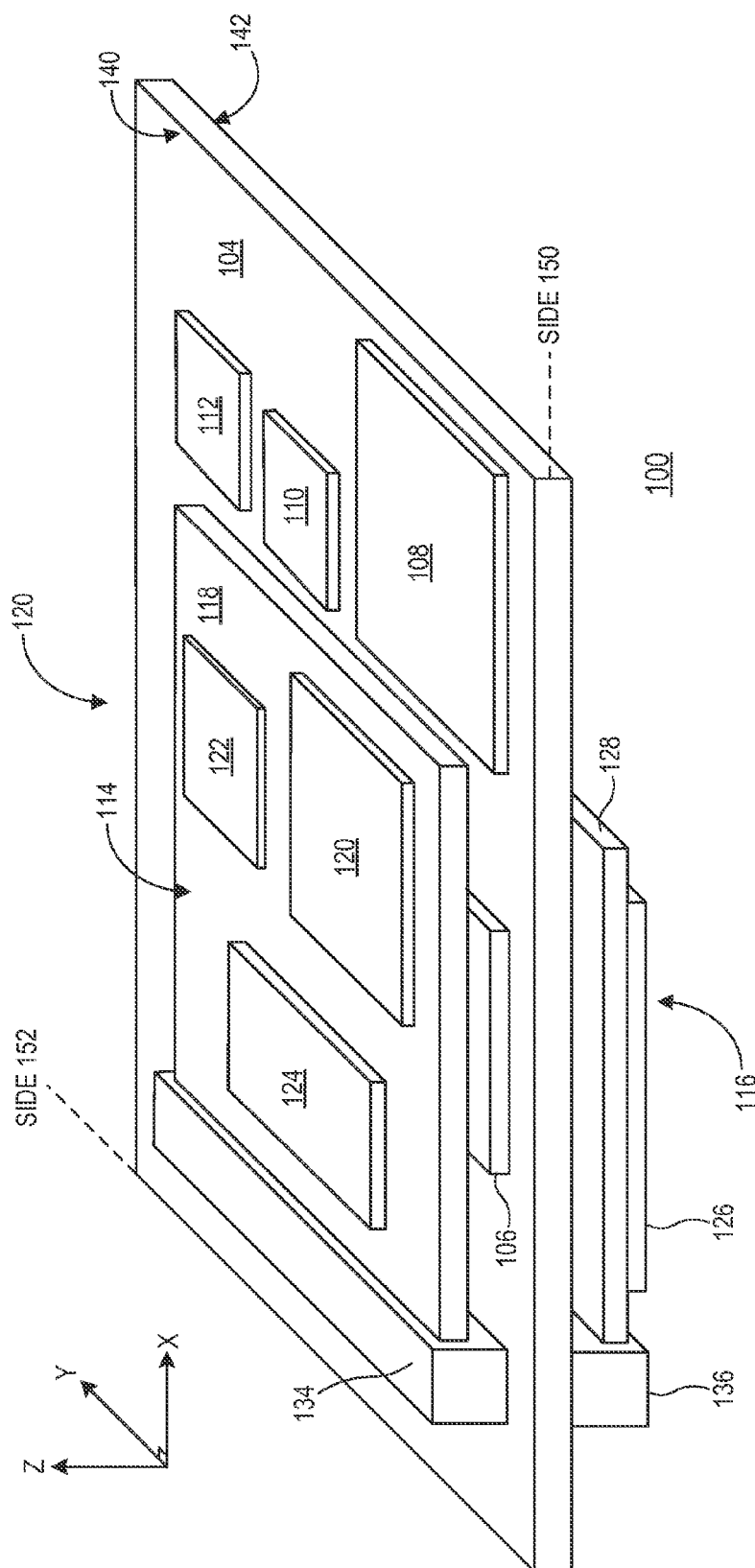
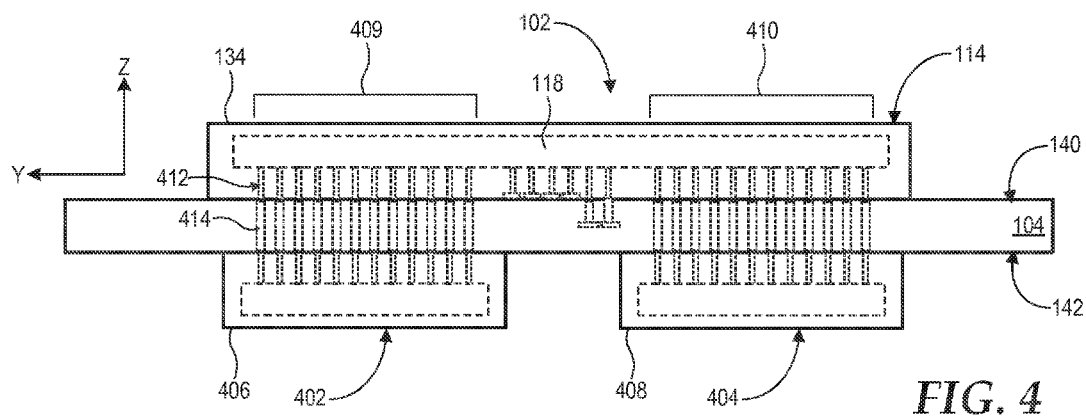
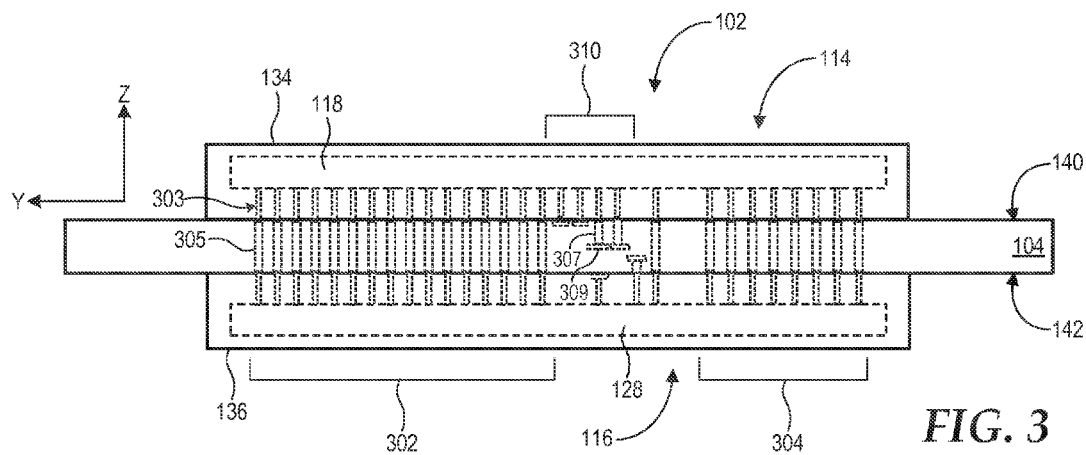
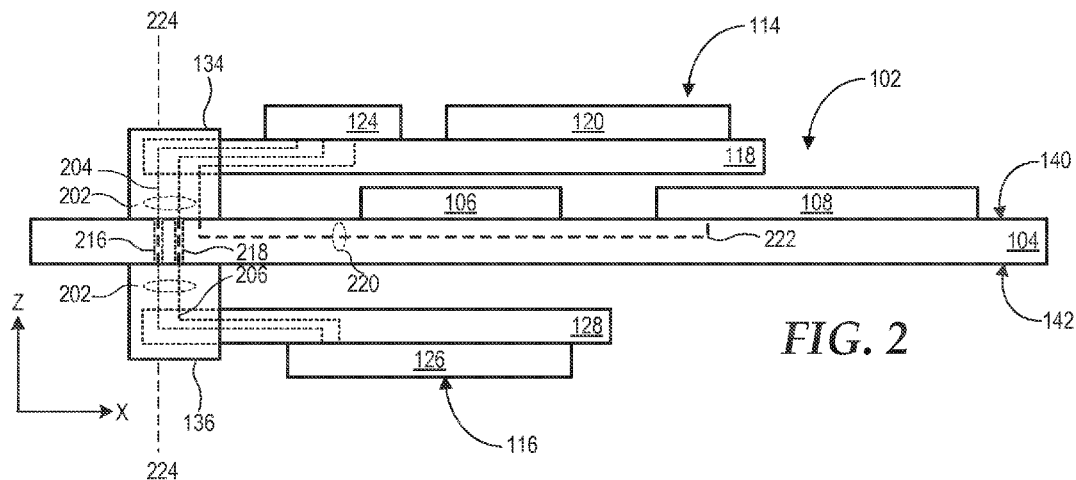


FIG. 1



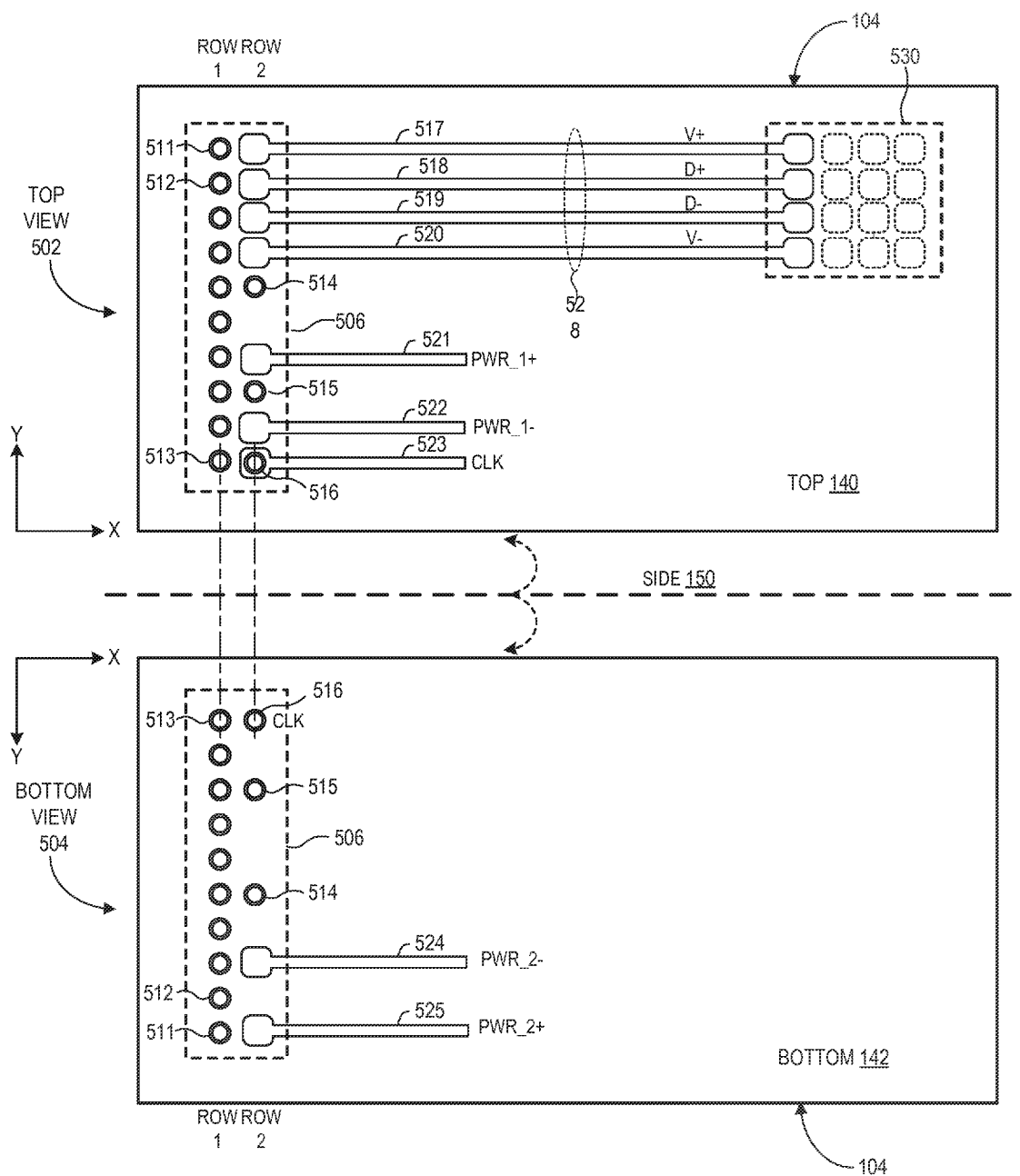
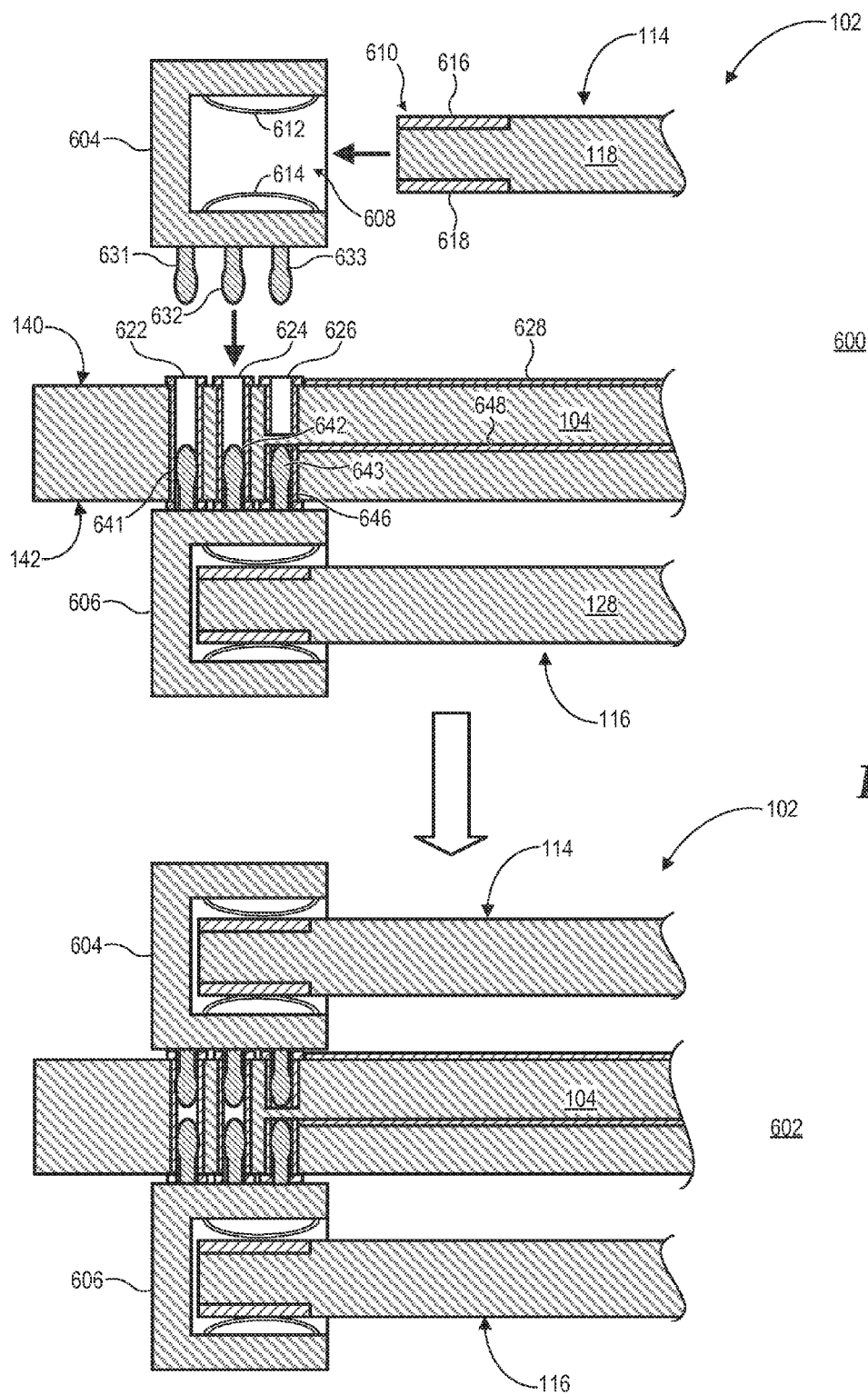
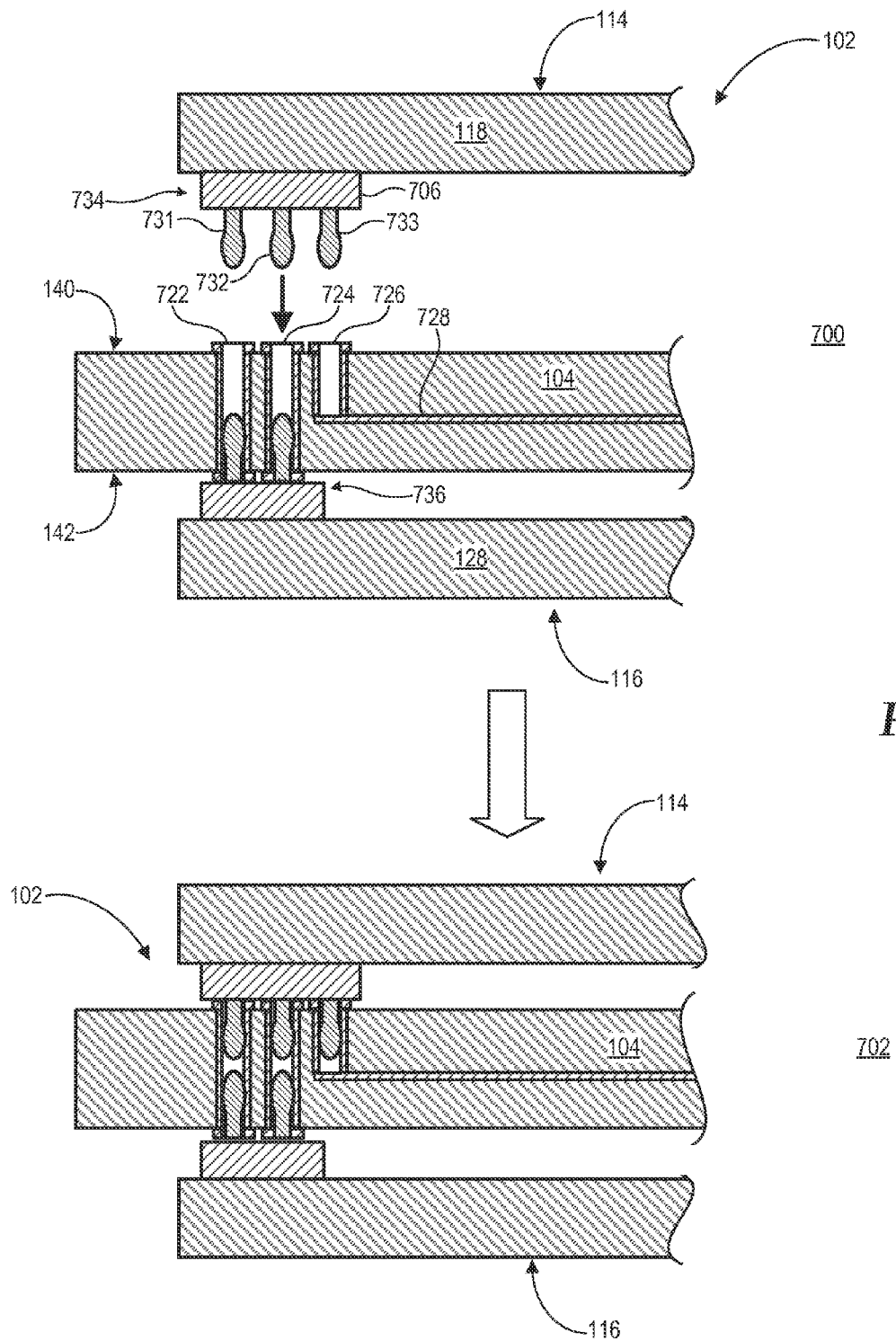


FIG. 5





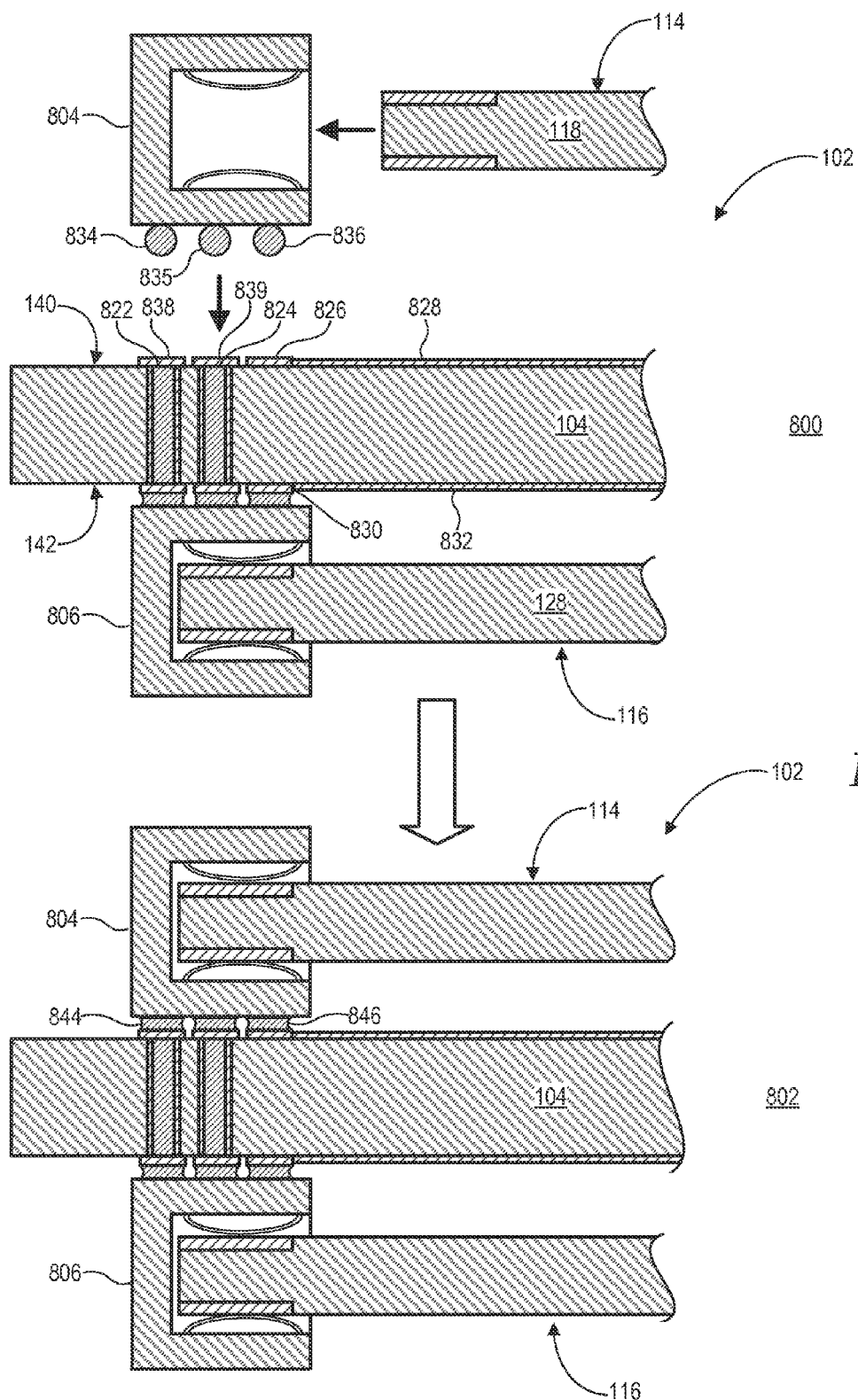
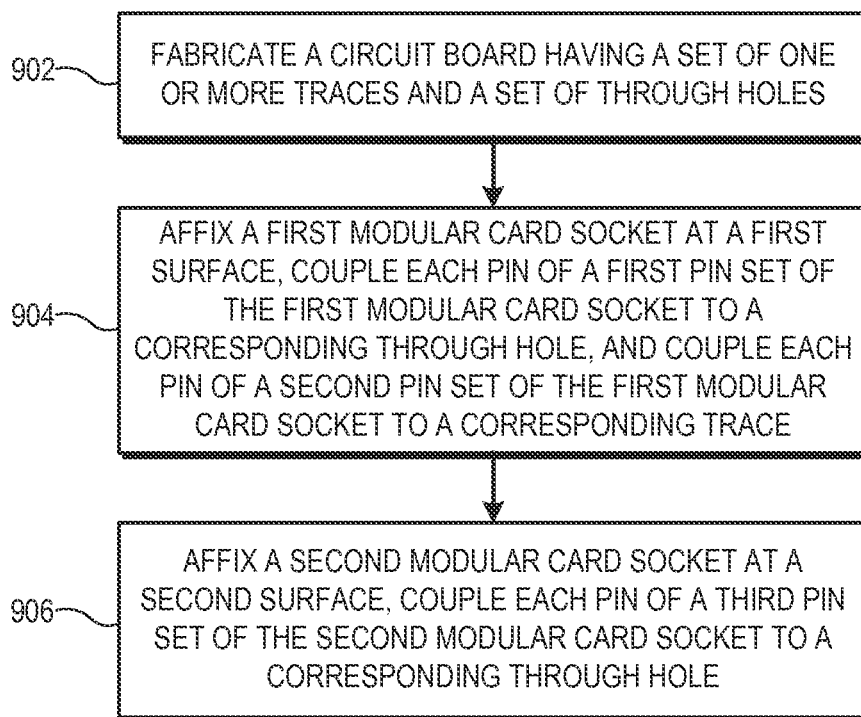


FIG. 8

900**FIG. 9**



# DOUBLE-SIDED CIRCUIT BOARD WITH OPPOSING MODULAR CARD CONNECTOR ASSEMBLIES

## BACKGROUND

### 1. Field of the Disclosure

The present disclosure generally relates to modular processing systems and more particularly relates to mounting and connecting modular cards using a circuit board.

### 2. Description of the Related Art

Circuit boards, such as motherboards and other printed circuit boards (PCBs), frequently are used to connect various electronic components of a system, both mechanically via sockets or solder joint connections and electrically via the various conductive traces of the circuit board. This arrangement is particularly common in computing systems, in which one or more processors, memory modules, and various peripheral components, such as input/output devices and power-conditioning components, are laterally disposed at the same surface of a motherboard and interconnected via lateral PCB traces at one or more metal layers of the motherboard. This arrangement often requires a relatively-large floorplan area for the motherboard and a relatively high number of metal layers in the motherboard, and can introduce latency, inter-signal skew, and other timing issues due to the relatively long and unmatched lengths of the lateral traces interconnecting the components disposed on the surface of the motherboard.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure may be better understood, and its numerous features and advantages made apparent to those skilled in the art by referencing the accompanying drawings. The use of the same reference numbers in different drawings indicates similar or identical items.

FIG. 1 is a diagram illustrating a perspective view of an electronic assembly with a dual-sided circuit board having opposing modular card connector assemblies in accordance with some embodiments.

FIG. 2 is a diagram illustrating a side view of the electronic assembly of FIG. 1 in accordance with some embodiments.

FIG. 3 is a diagram illustrating a rear view of the electronic assembly of FIG. 1 in accordance with some embodiments.

FIG. 4 is a diagram illustrating a rear view of an alternative implementation of the electronic assembly of FIG. 1 in accordance with some embodiments.

FIG. 5 is a diagram illustrating both a top plan view and a bottom plan view of a circuit board configured to connect opposing modular card connector assemblies in accordance with some embodiments.

FIG. 6 is a cross-section view of an electronic assembly employing opposing press-fit modular card sockets in accordance with some embodiments.

FIG. 7 is a cross-section view of an electronic assembly employing press-fit integrated modular card connections in accordance with some embodiments.

FIG. 8 is a cross-section view of an electronic assembly employing opposing surface-mount modular card sockets in accordance with some embodiments.

FIG. 9 is a flow diagram illustrating an example method for fabricating the electronic assembly of FIG. 1 in accordance with some embodiments.

## DETAILED DESCRIPTION

FIGS. 1-9 illustrate example embodiments of an electronic assembly that implements a dual-sided circuit board that pro-

vides reduced signal latency and reduced floorplan area relative to conventional circuit boards. The electronic assembly includes the dual-sided circuit board, which serves as both a mechanical attachment point and a signal conduit for electronic components of a processing system. The circuit board includes two opposing modular card connector assemblies disposed on opposing surfaces of a mounting region of the circuit board, and whereby pins of one of the modular card connector assemblies are connected to corresponding pins of the other modular card connector assembly via corresponding through holes extending between the opposing surfaces. Further, pins of one or both the modular card connector assemblies may be connected to other integrated circuit devices or other system components disposed at the circuit board via lateral traces of the circuit board. In some embodiments, one or both of the modular card connector assemblies comprises a modular card socket configured to removably mechanically and electrically couple with a corresponding modular card. In other embodiments, one or both of the modular card connector assemblies comprises a pin interface assembly that is integral to or otherwise fixedly attached to a corresponding modular card.

One or both of the modular card connector assemblies may be removably coupled to the circuit board through a press-fit relationship whereby press-fit pins of the modular card connector assemblies are inserted into the through holes to provide the electrical coupling between the modular card connector assemblies, as well as to facilitate mechanical coupling with the circuit board. A retention element, such as a pin, clamp, screw, or lever, may be used to augment the mechanical attachment between the modular card connector assemblies and the circuit board. In other embodiments, one or both of the modular card connector assemblies may be fixedly coupled to the circuit board through a surface mount technology, such as through solder ball reflow between pads of the modular card connector assembly and corresponding pads of the circuit board. The pads may be through-hole pads (that is, pads co-axial with the through-hole openings), offset pads escaped from the through holes via short escape traces, and the like.

The opposing positions of the modular card connector assemblies on opposite surfaces of the circuit board result in connections between pins of the modular card connector assemblies being primarily defined by the relatively short longitudinal distance between the two opposing surfaces (that is, the "thickness") of the circuit board. This is in contrast with conventional approaches whereby the connections between different components on a board are established via relatively long circuit board traces that extend laterally along a length or width of the circuit board. As such, the opposing positions of the modular card connector assemblies enables shorter signaling paths between the modular cards compared to conventional circuit board approaches. Accordingly, timing constraints for signals between components may be relaxed relative to conventional circuit board implementations. Moreover, because the opposing positions of the modular card connector assemblies enables the use of through holes for longitudinal conductivity paths in the circuit board, fewer lateral metal traces are needed to establish conductivity paths between components, thereby enabling the circuit board to have one or both of a smaller floorplan or fewer metal layers while providing the same connectivity compared to conventional circuit boards that rely on lateral trace connections between the components.

FIG. 1 illustrates a perspective view of a processing system 100 implementing a modular card electronic assembly 102, in accordance with some embodiments. The modular card elec-

tronic assembly **102** includes a circuit board **104**, which comprises, for example, a printed circuit board (PCB), and may be implemented as a motherboard or backplane. The circuit board **104** functions as both the mechanical attachment point for system components and as the means by which power, clocks, and other signals are routed among the system components.

These system components can include individual integrated circuit (IC) devices, individual discrete circuit devices (such as resistors, capacitors, and inductors) and other individually electronic devices disposed at a surface of the circuit board **104**, either directly using wire leads or surface mount technology (SMT) leads, or indirectly using a package socket, such as a land grid array (LGA) socket to receive a LGA-based IC package. A network interface controller (NIC) **106**, an input/output (I/O) controller **108**, a voltage regulator **110**, and a read-only memory (ROM) **112** as depicted in FIG. **1** are examples of such individually-mounted system components.

To facilitate the swapping out of groups of system components for purposes of repair, upgrading, and the like, certain system components may be aggregated onto modular cards, such as modular cards **114** and **116**, which in turn are mechanically and electrically coupled to the circuit board **104**. These modular cards (also referred to as a “add-in boards”, “expansion cards”, “blades”, and “daughterboards”) include a printed circuit board, or “card”, upon which one or more IC devices, discrete circuit devices, and the like, are disposed. The card includes metal interconnects in the form of vias and traces to provide connectivity among the components of the modular card, as well as to provide connectivity with the pins of the card which interface with corresponding pins of the circuit board **104**. Examples of such modular cards include graphics cards to handle graphics processing tasks, memory modules to provide system memory, network interface cards to provide network connectivity, disk drive controller cards to control hard disk drives or optical drives, and processor cards (e.g., server blades) to handle software execution tasks.

The modular cards **114** and **116** are mechanically and electrically coupled to the circuit board **104** via modular card connector assemblies **134** and **136**, respectively. As illustrated in greater detail below with reference to FIGS. **6** and **8**, in some embodiments one or both of the modular card connector assemblies **134** and **136** are implemented as modular card sockets configured to removably attach to a card edge of the corresponding modular card, and whereby conductive paths are established between sets of card edge contacts of the modular card and corresponding sets of contact pins of the modular card socket. The modular card socket may be configured so as to removably attach to the circuit board **104** via press-fit pins or other retention elements. As illustrated in greater detail below with reference to FIG. **7**, one or both of the modular card connector assemblies **134** and **136** may be pin interface assemblies that are integrated with, or otherwise fixedly attached to, the corresponding modular card. In such instances, the modular card may be removably attached to the circuit board **104** via press-fit pins or other retention elements of the corresponding modular card connector or the modular card may be fixedly attached to the circuit board **104** via solder joints, adhesive, thermo bonding, or other relatively permanent affixing mechanisms.

In the example of FIG. **1**, the modular card **114** comprises a processing card having one or more software-execution related components disposed at one or both mounting surfaces of a PCB **118**. Examples of such components can include one or more processors **120**, one or more power

regulators **122**, and a memory controller **124** or other I/O controller. The modular card **116** includes a memory card, or memory module, having one or more memory ICs **126** disposed at one or both mounting surfaces of a PCB **128**. The memory ICs **126** can implement any of a variety of memory architectures, including, but not limited to, volatile memory architectures such as dynamic random access memory (DRAM), synchronous DRAM (SDRAM), and static random access memory (SRAM), or non-volatile memory architectures, such as read-only memory (ROM), flash memory, ferroelectric RAM (F-RAM), magnetoresistive RAM (MRAM), and the like. To illustrate, the modular card **116** can be implemented using a dual in-line memory module (DIMM) architecture, such as a single outline DIMM (SODIMM) architecture or microDIMM architecture.

In a conventional approach, the modular cards **114** and **116** would be disposed on the same mounting surface of a circuit board and connections between the modular cards would be established using traces extending laterally (that is, in parallel with the mounting surfaces of the circuit board) between the two modular cards. However, this approach requires excessive floorplan area for the circuit board in order to accommodate the routing of the lateral traces as well as the mounting area needed for the connector assemblies of the modular cards. Moreover, the lateral traces are relatively long and may be of uneven length due to complex trace routing issues, and thus can introduce undesirable latency and inter-signal skew differentials. Accordingly, to reduce or eliminate these issues, the modular card connector assemblies **134** and **136**, and thus the modular cards **114** and **116**, are disposed on opposing mounting surfaces of the circuit board **104** with the modular card connector assemblies **134** and **136** having opposing positions (that is, at least partially coextensive along a plane perpendicular to the opposing mounting surfaces) such that connections between pins of the modular card connector assemblies **134** and **136** can be formed using through holes extending between the opposing mounting surfaces. In the example of FIG. **1**, the modular card connector assembly **134** and modular card **114** are disposed at a top mounting surface **140** and the modular card connector assembly **136** and modular card **116** are disposed at a bottom mounting surface **142** (“top” and “bottom” being relative to the orientation depicted in FIG. **1**). The modular card connector assemblies **134** and **136** are disposed at opposite surfaces of the same mounting region of the circuit board **104** so as to be in opposing positions relative to each other.

This opposing mounting of the modular card connector assemblies **134** and **136** and the use of through holes in the circuit board to establish the intended conductive paths between the modular card connector assemblies **134** and **136** results in shorter conductive paths between the modular cards **114** and **116** compared to conventional approaches as the conductive paths between the modular card connector assemblies **134** and **136** need only traverse the circuit board **104** longitudinally rather than laterally along the circuit board **104**. Moreover, because the conductive paths between the modular card connector assemblies **134** and **136** are relatively equal in length, there typically is less inter-signal skew between the modular connector assemblies **134** and **136** compared to lateral PCB trace implementations, thereby reducing the need to employ the various deskew techniques often used to attempt to equalize the lengths of the multiple lines of a bus implemented using lateral traces. For example, conventional approaches use extensive serpentine of PCB traces in an attempt to equalize the frequently disparate lengths of the traces used to implement a bus in the circuit board. Due to the relatively shorter and more equal conductive path lengths

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afforded by the coaxial positioning of the modular card connector assemblies **134** and **136**, less equalization is needed, thereby allowing either serpentine traces to be implemented on the modular card rather than the circuit board **104**, or allowing serpentine of traces to be omitted altogether, thereby relaxing the constraints on the trace routing for the circuit board **104**.

FIG. **2** illustrates a side view of the electronic assembly **102** from side **150** (FIG. **1**) in accordance with some embodiments. As shown, the modular card **114** is connected to the top mounting surface **140** of the circuit board **104** via the modular card connector assembly **134** and the modular card **116** is connected to the bottom surface **142** of the circuit board **104** via the modular card connector assembly **136**, and wherein the modular card connector assemblies **134** and **136** are coplanar and coextensive, that is, disposed at opposite sides of the same mounting region of the circuit board **104**.

The one or more processors **120** of the modular card **114** operate to execute software e.g., executable instructions) using data and instructions stored in the one or more memory ICs **126** of the modular card **116**. To enable the transfer of data and instructions between the one or more processors **120** and the memory ICs **126**, the memory controller **124** of the modular card **114** conducts signaling with the modular card **116** via a memory bus **202** implemented using conductive paths (e.g., conductive paths **204** and **206**) that incorporate corresponding sets of pins of the modular card **114**, the modular card connector assembly **134**, the modular card connector assembly **136**, and the modular card **116**. The conductive paths of the memory bus **202** traverse the circuit board **104** longitudinally using through holes, such as through holes **216** and **218**, that extend from the top mounting surface **140** to the bottom mounting surface **142**. The memory bus **202** can conduct the various signaling typically found in memory bus architectures or memory interface architectures, including data signaling, address signaling, timing signaling, control signaling, and the like. Other busses or inter-card interconnects can be implemented in a similar manner.

One or both of the modular cards **114** and **116** also may conduct signaling with individual system components disposed at the circuit board **104** or with other modular cards (not shown) disposed at the circuit board **104**. To illustrate, signaling between the I/O controller **108** and the memory controller **124** may be conducted via a peripheral bus **220** implemented as a set of conductive paths (e.g., conductive path **222**) formed between the memory controller **124** and the I/O controller **108** using a set of one or more pins of the modular card **114**, a corresponding set of one or more pins of the modular card connector assembly **134**, corresponding set of one or more lateral traces of the circuit board **104**, and a corresponding set of one or more pins of the I/O controller **108**. The lateral traces of the circuit board **104** may be implemented at one or more metal layers of the circuit board **104**, and traces below the surface layer of the circuit board **104** can include vias or through holes to facilitate connection between the corresponding pins of the modular card connector assembly **134** and the traces of the circuit board.

FIG. **3** illustrates a side view of the electronic assembly **102** from side **152** (FIG. **1**) in accordance with some embodiments. FIG. **3** also illustrates an example pinout configuration of the modular card connector assemblies **134** and **136** for a pin row that lies along a plane **224** (FIG. **2**) is also illustrated relative to the illustrated side view. In the depicted example, the memory bus **202** between the modular card connector assembly **134** and the modular card connector assembly **136** is implemented as a data/address sub-bus **302** and a control sub-bus **304**. The data/address sub-bus **302** includes sixteen

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bus lines **303**, or conductive paths, in the illustrated pin row, whereby the bus lines are implemented in part using a set of through hole vias **305** extending between the mounting surfaces **140** and **142** of the circuit board **104** and corresponding sets of pins of the modular card connector assemblies **134** and **136**. The control sub-bus **304** includes eight bus lines **303** in the illustrated pin row, which are likewise implemented using a sets of through holes **305** of the circuit board **104** and corresponding sets of pins of the modular card connector assemblies **134** and **136**. The peripheral bus **220** includes four bus lines in the illustrated pin row, whereby these bus lines are implemented in part using a set of lateral traces **307** and, if the traces are not surface traces, vias **309**. The electronic assembly **102** may be likewise configured for buses or other interconnects to facilitate signaling between the modular card connector assembly **136** and other system components disposed at the circuit board **104**.

Although example embodiments having two modular card connector assemblies (and thus two modular cards) on opposing sides of a mounting region of the circuit board **104** are primarily described herein for ease of illustration, in other embodiments, more than two modular card connector assemblies may be disposed on opposing sides of a mounting region of the circuit board **104**. FIG. **4** illustrates a side view from side **152** (FIG. **2**) of an alternative example of the electronic assembly **102** that employs more than two coplanar modular card connector assemblies. In the depicted example, the modular card **114** is longitudinally connected (relative to the circuit board **104**) to two modular cards **402** and **404** via modular card connector assemblies **406** and **408**, which are disposed at the bottom mounting surface **142** opposite to the modular card connector assembly **134** disposed in the same mounting region at the top mounting surface **140**. In this example, the modular cards **402** and **404** each could comprise a memory module card separately controlled by the memory controller **124** via a corresponding one of memory busses **409** and **410** implemented using conductive paths **412** implemented in part by sets of through holes **414** disposed between the modular card connector assemblies **406** and **408** and the modular card connector assembly **134**.

FIG. **5** illustrates plan views **502** and **504** of the top mounting surface **140** and bottom mounting surface **142**, respectively, of an example implementation of the circuit board **104** of the electronic assembly **102** in accordance with some embodiments. The plan views **502** and **504** are oriented in FIG. **5** relative to the side **150** (FIG. **1**). In the depicted example, the circuit board **104** includes a mounting region **506** defined by coextensive, opposing regions of the mounting surfaces **140** and **142** of the circuit board **104**. Formed within the mounting region **506** are various metal interconnect structures to facilitate electrical connections between the pins of the modular card connector assembly **134** (FIG. **1**) to be mounted within the mounting region **506** at the top mounting surface **140** and to facilitate electrical connections between the pins of the modular card connector assembly **136** (FIG. **1**) to be mounted within the mounting region **506** at the bottom mounting surface **142**. These metal interconnect structures include through holes to facilitate longitudinal electrical connections between the pin sets of the modular card connector assembly **134** and the corresponding pin sets of the modular card connector assembly **136**. These metal interconnect structures also can include lateral traces, blind vias, back-drilled through holes, or plated through holes to facilitate lateral electrical connections between pin sets of the modular card connector assemblies and pin sets of other components disposed at the mounting surfaces of the circuit board **104**.

In the depicted example, the pinout configuration of the mounting region **506** employs two rows of contacts. One row, identified as “Row 1” is composed entirely of through holes, such as through holes **511**, **512**, and **513**, to provide electrical contact between corresponding pins of the modular card connector assemblies **134** and **136**. The other row, identified as “Row 2”, is implemented as a combination of through holes, such as through holes **514**, **515**, and **516**, and lateral interconnect structures, such as lateral traces **517**, **518**, **519**, **520**, **521**, **522**, **523**, **524**, and **525**. While the lateral traces **517-525** are shown as surface traces in FIG. **5** for ease of illustration, some or all of the lateral traces **517-525** may be implemented as buried traces at one or more sub-surface metal layers of the circuit board **104**. Moreover, although not illustrated in FIG. **5**, through holes, press-fit holes, coaxial blind vias, back-drilled plated through holes, or solder pads may be implemented in those pin out locations that are not used to conduct signaling so as to provide additional points of attachment for the corresponding modular card connector assembly.

The through holes of Row 1 and certain through holes of Row 2, such as through holes **514** and **515**, may together implement the portion of the memory bus **202** (FIG. **2**) disposed between the corresponding pin set of the modular card connector assembly **134** and the corresponding pin set of the modular card connector assembly **136**. The lateral traces **517-525** facilitate electrical contact between pins of the modular card connector assemblies **134** and **136** and various components disposed at the circuit board **104**. For example, the trace set of lateral traces **517-520** implements the power lines and data lines of a Universal Serial Bus **528** to connect pins of the modular card connector assembly **134** to the corresponding pin set of an IC device **530** surface mounted to the top mounting surface **140** of the circuit board **104**. As another example, the lateral traces **521** and **522** are used as a trace set to distribute power from one power domain (denoted “PWR\_1”) to the modular card connector assembly **134** and the later traces **524** and **525** are used as a trace set to distribute power from another power domain (denoted “PWR\_2”) to the modular card connector assembly **136**. In some instances, certain signaling may be conducted between another system component and both of the modular card connector assemblies **134** and **136** using a combination of a through hole and a lateral trace. For example, a clock source (not shown) disposed at the top mounting surface **140** can distribute a clock signal (denoted “CLK”) to both a pin of the modular card connector **134** and a pin of a modular card connector **136** via the through hole **516** and the lateral trace **523**, which is electrically coupled to the through hole **516** through, for example, a capture pad formed at the through hole **516**.

In some embodiments, the electronic assembly **102** can take advantage of unnecessary or unused signal capabilities provided by standard sockets to enable both longitudinal signaling between the modular cards **114** and **116** and lateral signaling between one or both of the modular cards **114** and **116** and other system components on the circuit board **104**. In such instances, the socket pins that otherwise would be used to conduct unnecessary or unused signaling can instead be repurposed to facilitate signaling with system components laterally disposed relative to the socket. To illustrate, the electronic assembly **102** may implement a standard 200-pin SODIMM DRAM socket as the modular card connector assembly **134** to as to couple with a 200-pin SODIMM DRAM memory module (one example of the modular card **116**). The standard pin assignment for the 200-pin SODIMM DRAM architecture assigns pins **10**, **26**, **52**, **67**, **130**, **147**, **170**, and **185** for use in specifying an 8-bit input data mask for write data. If this data mask capability is not implemented or

otherwise not necessary in an implementation of the processing system **100** using 200-pin SODIMM DRAM, then four of the eight pins that otherwise would be used to implement this data mask in the memory bus signaling instead can be repurposed to provide connectivity between the modular card **114** and the traces **517-520** implementing the USB **528**. As such, this standard socket can be used as both the conduit for longitudinal signaling with the opposite modular card, as well as for lateral signaling with laterally positioned system components.

FIGS. **6-8** illustrate alternative cross-section views of a portion of the electronic assembly **102** along a plane parallel with side **150** (FIG. **1**) in accordance with various embodiments. Referring initially to FIG. **6**, cross-section views **600** and **602** of the electronic assembly **102** depict an example implementation whereby the modular card connector assemblies **134** and **136** are implemented as card sockets **604** and **606**, respectively, which have a press-fit relationship with the circuit board **104**. The card sockets **604** and **606** can comprise any of a variety of standardized or proprietary socket types, and may comprise the same or different socket types. To illustrate, the card socket **604** and the card socket **606** each implement a particular SODIMM socket, which would enable straightforward configuration of the pinouts between sets of pins of the card sockets **604** and **606**. As another example, the card socket **604** can comprise a Peripheral Component Interconnect-Express (PCI-E) socket and the card socket **606** can comprise a microDIMM socket.

The card sockets **604** and **606** each have a socket opening **608** to receive a card edge **610** of the corresponding one of PCBs **118** and **128**. The socket opening **608** comprises a plurality of contacts, such as contacts **612** and **614**, to physically contact corresponding card edge contacts, such as card edge contacts **616** and **618**, at the card edge **610**, thereby providing electrical connections between the card socket and the corresponding modular card. Note that although FIG. **6** illustrates the sockets in a right-angle configuration so as to orient the corresponding received PCB parallel to the circuit board **104**, the sockets may orient the corresponding PCB at any angle, such as an orientation that is perpendicular to the mounting surface of the circuit board **104** or orientation that is 45 degrees relative to the mounting circuit board **104**. In some embodiments, the modular card and the corresponding card socket are configured to provide a “press-fit” relationship that forms a friction coupling that helps maintain the connector assemblies in position under expected operational conditions. This press-fit relation thereby allows the modular card to be removably attachable to the card socket, and thus permits swapping between different modular cards. This press-fit relationship can be implemented through friction or pressure placed on the card edge contacts by the corresponding contacts of the socket opening **608** and through friction or pressure placed on the card edge **610** by one or more walls of the socket opening **608**. A retention element, such as a pin, clamp, screw, or lever, also may be used to augment the mechanical attachment.

The card sockets **604** and **606**, in turn, have a press-fit relationship with the circuit board **104** so as to allow the card sockets **604** and **606** to be removably attachable to the circuit board **104**. In some embodiments, this press-fit relationship is implemented through the use of sets of press-fit pins on the board-facing side of the card socket, which are inserted into corresponding through holes in the mounting region of the circuit board so as to provide both mechanical coupling through the friction between the press-fit pins and the walls of the through holes and electrical coupling through the metal material of the press-fit pins and the metal-plated walls of the

through holes. In the illustrated example, the card socket **604** implements three rows of press-fit pins, including press-fit pins **631**, **632**, and **633**, and the card socket **606** implements three rows of press-fit pins, including press-fit pins **641**, **642**, and **643**. The press-fit pins of the card socket **604** are electrically connected to corresponding contacts of the socket opening **608** of the card socket **604** and the press-fit pins of the card socket **606** are electrically connected into the corresponding contacts of the socket opening **608** of the card socket **606**.

Cross-section views **600** and **602** illustrate an example whereby the circuit board **104** implements two rows of through holes, including through holes **622** and **624**, to provide longitudinal signaling between the card sockets **604** and **606**. The through holes may be formed by, for example, drilling corresponding holes through the circuit board **104** and then plating the walls and a portion of the surfaces surrounding the hole openings with metal or other conductive material so as to form a plated through hole (PTH) that provides a continuously conductive structure that extends from the top mounting surface **140** to the bottom mounting surface **142**.

The circuit board **104** further implements a third row of pin outs in the mounting region at the top mounting surface **140** and the bottom mounting surface **142** comprising coaxial holes that serve as mechanical attachment points for corresponding press-fit pins and may facilitate lateral signaling with other components on the circuit board **104** for the card socket **604** and the card socket **606**, respectively. These coaxial holes can include coaxial blind vias comprising plated barrels on both sides of the circuit board **104** but without a through hole connecting them. A pair of coaxial holes also may be implemented as a back-drilled plated through hole in which a through hole with a plated barrel is formed and then a secondary process is performed to partially remove the plated barrel on one side of the through hole so that a pin inserted on that side is not brought into electrical contact with the plating of the remainder of the through hole. The depicted example illustrates an implementation of these coaxial holes as coaxial blind vias **626** and **646**. The blind via **626** at the top surface **140** is coupled to a surface trace **628** and functions as a press-fit hole so as to receive a corresponding press-fit pin **633** of the card socket **604**. Likewise, the blind via **646** at the bottom surface **142** is coupled to a buried trace **648** and functions as a press-fit hole on as to receive a corresponding press-fit pin **643** of the card socket **606**. One or both of the conductive structure formed by the blind via **626** and the trace **628** and the conductive structure formed by the blind via **646** and the trace **648** may be used for conducting lateral signaling between the corresponding card socket and other components on the circuit board **104**. In instances whereby the corresponding socket pin is inactive, the through hole or blind via may be grounded (or pulled up to a voltage). To illustrate, the processing modular card **114** may use the press-fit pin **633** to conduct lateral signaling, whereas the coaxial press-fit pin **643** may be intended to be inactive and thus the blind via **646** may be coupled to a ground potential via the buried trace **648**.

Accordingly, as illustrated by cross-section view **602**, after the card sockets **604** and **606** are attached to the corresponding mounting surfaces of the circuit board **104** and the module cards **114** and **116** are attached to the corresponding card sockets **604** and **606**, respectively, longitudinal conductive paths are created between the modular cards **114** and **116** via the card sockets **604** and **606** and the through holes formed therebetween. Moreover, a lateral conductive path is created between the modular card **114** and another component on the

circuit board **104** via the card socket **604**, the press-fit pin **633**, the blind via **626**, and the surface trace **628**.

FIG. 7 illustrates cross-section views **700** and **702** of the electronic assembly **102** for an example implementation whereby the modular card connector assemblies **134** and **136** are implemented as pin interface assemblies **734** and **736** that are integral, or fixedly attached, components of the modular cards **114** and **116**, respectively, and which have a press-fit relationship with the circuit board **104**. In the example of FIG. 7, the circuit board **104** is configured in a similar manner as described above with reference to FIG. 6, whereby the circuit board **104** includes two rows of through holes, such as through holes **722** and **724**, to provide longitudinal signaling between the modular cards **114** and **116**, and a third row to provide pin outs in support of lateral signaling with other system components. In this example, the third row includes a blind via **726** providing access to a buried trace **728**, which in turn may be connected to a pin of another system component or connected to a voltage or ground terminal of a power source.

As illustrated by cross-section view **700**, the pin interface assembly **734** implements, in this example, a connector base **706** having one or more rows of press-fit pins, such as press-fit pins **731**, **732**, and **733**, which are connected to the metal interconnect structures (not shown) of the modular card **114**. The connector base **706** is illustrated as affixed to an edge of the modular card **114**, but in other embodiments the connector base **706** may be affixed to other locations of the modular card **114**. The connector base **706** may be fixedly attached to, or integrated with, the PCB **118** of the modular card **114** using, for example, an adhesive, thermo bonding, and the like. In other embodiments, the press-fit pins of the modular card connector assembly **134** are attached directly to the PCB **118**. The pin interface assembly **736** may be configured with respect to the modular card **116**.

As illustrated by cross-section view **702**, after the modular cards **114** and **116** have been attached to the circuit board **104** via the press-fit pins, longitudinal conductive paths are formed between the circuitry of the modular card **114** and the modular card **116** via the through holes of the circuit board and corresponding pin sets of press-fit pins of the modular cards **114** and **116**. Moreover, a lateral conductive path is formed between the circuitry of the modular card **114** and another component on the circuit board **104** using the blind via **726** and the buried trace **728**.

FIG. 8 illustrates cross-section views **800** and **802** of the electronic assembly **102** for an example implementation whereby the modular card connector assemblies **134** and **136** are implemented as card sockets **804** and **806**, respectively, which are fixedly attached to the circuit board **104**. The card sockets **804** and **806** are configured in a similar manner as described above with reference to the card sockets **604** and **606**. However, rather than using press-fit pins to connect to the corresponding pin out configuration of the circuit board **104**, the card sockets **804** and **806** employ a surface mount technology (SMT) to fixedly attach the pins of the card sockets **804** and **806** to the circuit board **104**.

For example, cross-section views **800** and **802** illustrate an example whereby the circuit board **104** implements two rows of through holes, including through holes **822** and **824**, to provide longitudinal signaling between the card sockets **804** and **806** and a third row of pin outs in the mounting region at both the top mounting surface **140** and the bottom mounting surface **142** to provide lateral signaling with other components on the circuit board for the card sockets **804** and **806**. This lateral signaling including, for example, solder pad **826** connected to a surface trace **828** at the top mounting surface **140** and a solder pad **830** connected to a surface trace **832** at

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the bottom mounting surface **142**. Accordingly, the card socket **804** and the card socket **806** each implements three rows of solder pads and bumps, such as solder bumps **834**, **835**, and **836**, to couple each pad of the card socket to the corresponding solder pad of the circuit board **104**. As illustrated by cross-section view **800**, the circuit board **104** can use capture pads, such as capture pads **838** and **839**, located over the through holes as the solder pads used to connect to the corresponding pad of the card socket. In other embodiments, short escape traces can be used to route the solder pads a short distance away from the through holes.

As illustrated by cross-section view **802**, after the card sockets **804** and **806** have been surface mounted to the corresponding solder pads of the circuit board **104** and the module cards **114** and **116** are attached to the corresponding card sockets **804** and **806**, respectively, longitudinal conductive paths are created between the modular cards **114** and **116** via the card sockets **804** and **806** and solder joints (e.g., solder joint **844**) and through holes formed therebetween. Moreover, a lateral conductive path is created between the modular card **114** and another component on the circuit board **104** via the card socket **804**, the solder joint **846** resulting from reflow of the solder bump **836**, and the surface trace **828**. Likewise, a lateral conductive path is created between the modular card **116** and another component on the circuit board via the card socket **806** and a solder joint connecting the solder pad **830** and the surface trace **832** to the corresponding pin of the card socket **806**.

Although FIGS. **6-8** illustrate various embodiments whereby the modular card connector assemblies **134** and **136** are of the same type of assembly, in other embodiments, they may be of different types of assembly. To illustrate, the modular card connector assembly **134** may be implemented as the fixedly attached card socket **804** of FIG. **8** while the modular card connector assembly **136** is implemented as the press-fit-type card socket **604** of FIG. **6**.

FIG. **9** illustrates an example method **900** for fabricating the electronic assembly **102** in accordance with some embodiments. The method **900** includes fabricating a circuit board comprising a set of one or more traces and a set of through holes extending between a first surface of the circuit board and an opposing second surface of the circuit board at block **902**. At block **904**, the method **900** includes affixing a first modular card socket at the first surface of the circuit board, coupling each pin of a first pin set of one or more pins of the first modular card socket to a corresponding through hole of the set of through holes, and coupling each pin of a second pin set of one or more pins of the first modular card socket to a corresponding trace of the set of one or more traces. At block **906**, the method **900** additionally includes affixing a second modular card socket at the second surface of the circuit board and coupling each pin of a second pin set of one or more pins of the second modular card socket to a corresponding through hole of the set of through holes. As noted above, each pin of the first pin set can comprise a press-fit pin, such that coupling each pin of the first pin set to a corresponding through hole comprises inserting a press-fit pin into the corresponding through hole. In other embodiments, coupling each pin of the first pin set to a corresponding through hole comprises coupling the pin to the corresponding through hole via a solder joint.

Note that not all of the activities or elements described above in the general description are required, that a portion of a specific activity or device may not be required, and that one or more further activities may be performed, or elements

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included, in addition to those described. Still further, the order in which activities are listed are not necessarily the order in which they are performed.

Also, the concepts have been described with reference to specific embodiments. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the present disclosure as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of the present disclosure.

Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any features that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature of any or all the claims.

What is claimed is:

1. An electronic assembly comprising:

a circuit board comprising:

a set of through holes extending between a first surface of the circuit board and an opposing second surface of the circuit board;

a first modular card socket disposed at the first surface of the circuit board, the first modular card socket having a first pin set of one or more pins, each pin of the first pin set coupled to a corresponding through hole of the set of through holes; and

a second modular card socket disposed opposite the first modular card socket at the second surface of the circuit board, the second modular card socket having a second pin set of one or more pins, each pin of the second pin set coupled to a corresponding through hole of the set of through holes.

2. The electronic assembly of claim 1, wherein each pin of the first pin set comprises a press-fit pin inserted in the corresponding through hole.

3. The electronic assembly of claim 1, wherein each pin of the first pin set comprises a solder joint coupled to a corresponding pad coupled to the corresponding through hole.

4. The electronic assembly of claim 1, further comprising: a first modular card inserted into the first modular card socket; and

a second modular card inserted into the second modular card socket.

5. The electronic assembly of claim 4, wherein:

the first modular card comprises a processing card having at least one processor; and

the second modular card comprises a memory module card having at least one memory integrated circuit; and

the first modular card and the second modular card conduct memory bus signaling using the first pin set, the set of through holes, and the second pin set.

6. The electronic assembly of claim 4, further comprising: an integrated circuit device disposed at the first surface of the circuit board and having a third pin set of one or more pins, each pin of the third pin set coupled to a corresponding trace of a set of one or more traces of the circuit board;

wherein the first modular card socket further comprises a fourth pin set of one or more pins, each pin of the fourth pin set coupled to a corresponding trace of the set of one or more traces; and

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wherein the first modular card and the integrated circuit device conduct bus signaling via the third pin set, the set of one or more traces, and the fourth pin set.

7. The electronic assembly of claim 1, wherein the first modular card socket further comprises a third pin set of one or more pins, each pin of the third pin set coupled to a corresponding trace of a set of one or more traces of the circuit board.

8. An electronic assembly comprising:

a circuit board having a first mounting surface and a second mounting surface opposite the first mounting surface, the circuit board comprising:

a set of through holes, each through hole extending between the first mounting surface and the second mounting surface; and

a first trace set of one or more traces;

a first modular card connector assembly disposed at the first mounting surface and comprising a first pin set of one or more pins and a second pin set of one or more pins, each pin of the first pin set comprising a press-fit pin inserted in a corresponding through hole of the set of through holes and each pin of the second pin set coupled to a corresponding trace of the first trace set; and

a second modular card connector assembly disposed at the second mounting surface opposite of the first modular card connector assembly and comprising a third pin set of one or more pins, each pin of the third pin set comprising a press-fit pin inserted in a corresponding through hole of the plurality of through holes.

9. The electronic assembly of claim 8, wherein the first modular card connector assembly comprises a first modular card socket having a socket opening to removably couple with a card edge of a modular card.

10. The electronic assembly of claim 9, wherein the second modular card connector assembly comprises a second modular card socket having a second opening to removably couple with a modular card.

11. The electronic assembly of claim 10, further comprising:

a first modular card coupled with the first modular card socket, the first modular card comprising:

a fourth pin set of one or more pins, each pin of the fourth pin set comprising a card edge contact electrically coupled to a corresponding pin of the first pin set via the socket opening of the first modular card socket;

a fifth pin set of one or more pins, each pin of the fifth set comprising a card edge contact coupled to a corresponding pin of the second pin set via the socket opening of the first modular card socket;

one or more processors; and

a memory controller coupled to the one or more processors and coupled to the fourth pin set of one or more pins; and

a second modular card coupled with the second modular card socket, the second modular card comprising:

a sixth pin set of one or more pins, each pin of the sixth pin set comprising a card edge contact electrically coupled to a corresponding pin of the third pin set via the socket opening of the second modular card socket; and

one or more memory integrated circuits electrically coupled to the sixth pin set of one or more pins.

12. The electronic assembly of claim 11, further comprising:

an integrated circuit device disposed at the first mounting surface of the circuit board, the integrated circuit device comprising a seventh pin set of one or more pins, each

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pin of the seventh pin set electrically coupled to a corresponding trace of the first trace set.

13. The electronic assembly of claim 9, wherein:

the second modular card connector assembly further comprises a fourth pin set of one or more pins; and

the circuit board further comprises:

a second trace set of one or more traces;

a first hole disposed at the first mounting surface, the first hole coupling a pin of the second pin set to the corresponding trace of the first trace set; and

a second hole disposed at the second mounting surface, the second hole coaxial with the first hole and coupling a pin of the fourth pin set to a trace of the second trace set.

14. The electronic assembly of claim 13, wherein the first hole and second hole comprise one of: coaxial blind vias; and a back-drilled plated through hole.

15. The electronic assembly of claim 8, further comprising: a first modular card disposed at the first mounting surface; and

wherein the first modular card connector assembly comprises a first pin interface assembly fixedly attached to the first modular card; and

wherein the first pin set comprises one or more press-fit pins of the first pin interface assembly.

16. The electronic assembly of claim 15, wherein:

the circuit board comprises a set of one or more press-fit holes, each press-fit hole coupled to a corresponding trace of the first trace set; and

the second pin set comprises one or more press-fit pins of the first pin interface assembly, each press-fit pin inserted in a corresponding press-fit hole of the set of one or more press-fit holes.

17. The electronic assembly of claim 15, further comprising:

a second modular card disposed at the second mounting surface; and

wherein the second modular card connector assembly comprises a second pin interface assembly fixedly attached to the second modular card; and

wherein the third pin set comprises one or more press-fit pins of the second pin interface assembly.

18. The electronic assembly of claim 17, wherein:

the first modular card comprises a processing modular card having one or more processors and a memory controller; and

the second modular card comprises a memory module card having one or more memory integrated circuits.

19. The electronic assembly of claim 8, further comprising: an integrated circuit device disposed at the first mounting surface, the integrated circuit device comprising a fourth pin set of one or more pins, each pin of the fourth pin set coupled to a corresponding trace of the set of traces.

20. A processing system comprising:

a circuit board comprising:

an integrated circuit device disposed at a first surface of the circuit board;

first modular card socket and a second modular card socket disposed at opposing surfaces of a mounting region of the circuit board;

a set of one or more traces electrically coupling a first pin set of one or more pins of the first modular card socket to a second pin set of one or more pins of the integrated circuit device; and

a set of through holes electrically coupling a third set of pins of the first modular card socket to a fourth set of pins of the second modular card socket;

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a processing modular card removably attached to the first modular card socket, the processing modular card comprising:

- a first set of card edge contacts, each card edge contact electrically coupled to a corresponding pin of the first pin set; 5
- a second set of card edge contacts, each card edge contact electrically coupled to a corresponding pin of the third pin set; 10
- one or more processors; 10
- a memory controller coupled to the first pin set and the second pin set; and

a memory modular card removably attached to the second modular card socket, the memory modular card comprising: 15

- a third set of card edge contacts, each card edge contact coupled to a corresponding pin of the fourth pin set; 15
- one or more memory integrated circuits; and
- wherein the memory controller and the memory integrated circuits are to conduct memory bus signaling via the first set of through holes; and 20
- wherein the memory controller and the integrated circuit device are to conduct bus signaling via the set of traces.

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**21.** A method of fabricating an electronic assembly, the method comprising:

- fabricating a circuit board comprising a set of one or more traces and a set of through holes extending between a first surface of the circuit board and an opposing second surface of the circuit board;

- affixing a first modular card socket at the first surface of the circuit board, coupling each pin of a first pin set of one or more pins of the first modular card socket to a corresponding through hole of the set of through holes, and coupling each pin of a second pin set of one or more pins of the first modular card socket to a corresponding trace of the set of one or more traces; and

- affixing a second modular card socket at the second surface of the circuit board and coupling each pin of a second pin set of one or more pins of the second modular card socket to a corresponding through hole of the set of through holes.

**22.** The method of claim **21**, wherein:

- each pin of the first pin set comprises a press-fit pin; and
- coupling each pin of the first pin set to a corresponding through hole comprises inserting a press-fit pin into the corresponding through hole.

\* \* \* \* \*